PROCEEDINGS.

Eight hundred and sixty-seventh Meeting.

May 9, 1894. — Annual Meeting.

The President in the chair.

The Corresponding Secretary read the following letters: from the Royal Society of London, on the project of making a catalogue of scientific papers by means of international co-operation; from the Royal Society of Canada, inviting the Academy to send delegates to its Twelfth General Meeting on the 22d of May; from Ad. de Marignac, announcing the death of his father, Jean Charles Galissard de Marignac, a Foreign Honorary Member of the Academy; and from Francis M. Green and W. C. Sabine, acknowledging their election into the Academy.

Voted, To accept the invitation of the Royal Society of Canada, and the President was authorized to appoint a delegate.

The Report of the Council of the Academy was read and accepted.

The Reports of the Librarian, of the Treasurer, and of the C. M. Warren Committee were read and accepted.

Notice of a proposed change in the statutes was given by Charles L. Jackson, viz. to increase the number of Vice-Presidents so as to have one from each Class. This proposal was referred to a Committee consisting of C. L. Jackson, S. H. Scudder, and F. W. Putnam.

The President appointed, as a Committee of Co-operation on the project of making a catalogue of scientific papers, C. L. Jackson, H. P. Bowditch, and Denman W. Ross.

H. P. Bowditch presented a motion in regard to independent nominations for the offices of the Academy, which was referred to the Committee on the changes in the statutes.

On the recommendation of the Committee of Finance, it was

Voted, To make the following appropriations from the income of the General Fund for the ensuing year: —

For the library	$1,200
For general expenses	2,500
For publications	1,800
For the expenses of meetings . . .	200

Voted, That the assessment for the ensuing year be five dollars.

Voted, That $1,000 from the Rumford Fund be placed at the disposal of the Rumford Committee, to be expended in aid of investigations on Light and Heat, payments to be made on the order of the Chairman of the Committee.

In accordance with the recommendation of the Committee on the proposed alteration of the statutes, it was

Voted, To amend Chapter V. of the Statutes by changing the numbers of sections 4, 5, and 6 to 5, 6, and 7, respectively, and inserting a new paragraph as follows: —

"4. The C. M. Warren Committee, of seven Fellows, to be chosen by ballot, who shall consider and report on all applications for appropriations from the income of the C. M. Warren Fund, and generally see to the due and proper execution of this trust."

The following gentlemen were elected members of the Academy: —

Walter Gould Davis, of Cordova, to be an Associate Fellow in Class II., Section 1 (Geology, Mineralogy, and Physics of the Globe), in place of the late William H. C. Bartlett.

Hermann Eduard von Holst, of Chicago, to be an Associate Fellow in Class III., Section 3 (Political Economy and History).

Ingram Bywater, of Oxford, to be a Foreign Honorary Member in Class III., Section 2 (Philology and Archæology), in place of the late Benjamin Jowett.

Sir John Robert Seeley, of Cambridge, to be a Foreign Honorary Member in Class III., Section 3 (Political Economy and History), in place of the late Charles Merivale.

The annual election resulted in the choice of the following officers: —

JOSIAH P. COOKE, *President.*
AUGUSTUS LOWELL, *Vice-President.*
CHARLES L. JACKSON, *Corresponding Secretary.*
WILLIAM WATSON, *Recording Secretary.*
ELIOT C. CLARKE, *Treasurer.*
HENRY W. HAYNES, *Librarian.*

Councillors.

WILLIAM R. LIVERMORE,
BENJAMIN O. PEIRCE,
BENJAMIN A. GOULD, } of Class I.

HENRY P. WALCOTT,
BENJAMIN L. ROBINSON,
HENRY W. WILLIAMS, } of Class II.

ANDREW M. DAVIS,
THOMAS W. HIGGINSON,
JAMES B. THAYER, } of Class III.

Member of the Committee of Finance.

AUGUSTUS LOWELL.

Rumford Committee.

JOHN TROWBRIDGE, EDWARD C. PICKERING,
ERASMUS D. LEAVITT, CHARLES R. CROSS,
BENJAMIN O. PEIRCE, AMOS E. DOLBEAR,
BENJAMIN A. GOULD.

C. M. Warren Committee.

FRANCIS H. STORER, SAMUEL CABOT,
THOMAS M. DROWN, HENRY B. HILL,
CHARLES L. JACKSON, LEONARD P. KINNICUTT,
ARTHUR M. COMEY.

The President appointed the following Standing Committees: —

Committee of Publication.

Charles L. Jackson, William G. Farlow,
Charles G. Loring.

Committee on the Library.

Henry P. Bowditch, Amos E. Dolbear,
Edward J. Lowell.

Auditing Committee.

Henry G. Denny, John C. Ropes.

On the motion of the Corresponding Secretary it was

Voted, That the thanks of the Academy be tendered to Wolcott Gibbs for his long and valuable services as member of the Rumford Committee.

The following papers were presented by title: —

On those Orthogonal Substitutions that are given by Cayley's Expression, or by the Limiting Form of Cayley's Expression. By Henry Taber.

On the Measurement of Resistance by the Method of Substitution. By G. Le Clear.

On the Currents in Batteries made up of Cells joined up in Multiple Arc. By B. O. Peirce.

On the Constitution of the Nitroparaffine Salts. Second Paper. By John U. Nef.

On Ternary Mixtures. First Paper: The Chemical Potential of Metals. By Wilder D. Bancroft.

Action of Alcoholates on Chloranil. By C. Loring Jackson and H. S. Grindley.

Bromine Derivatives of Metaphenylene Diamine. By C. Loring Jackson and S. Calvert.

Behavior of certain Derivatives of Benzol containing Halogens. By C. Loring Jackson and S. Calvert.

A Revision of the Atomic Weight of Strontium. First Paper: The Analysis of Strontic Bromide. By Theodore W. Richards.

On the Cupriammonium Double Salts. Second Paper. By Theodore W. Richards and A. H. Whitridge.

On the Cupriammonium Double Salts. Third Paper: Compounds of Iodine. By Theodore W. Richards and G. Oenslager.

On a Series of Cupraniline Compounds. By Theodore W. Richards and F. C. Moulton.

Euglenopsis, a new Alga-like Organism. By Bradley Moors Davis.

New Plants of Northwest Mexico, collected by Messrs. C. V. Hartman and C. G. Lloyd upon the Lumholtz Archæological Expedition. By B. L. Robinson and M. L. Fernald.

On the Cell Lineage of the Ascidian Egg. A Preliminary Notice. By W. E. Castle.

The North American Ceuthophili. By S. H. Scudder.

Researches on Electrical Waves. By John Trowbridge.

On the motion of the Corresponding Secretary, it was

Voted, That the Rumford Committee be directed to defray the cost of the publication of John Trowbridge's paper on "Electrical Waves" from the income of the Rumford Fund.

Eight hundred and sixty-eighth Meeting.

October 10, 1894. — STATED MEETING.

The VICE-PRESIDENT in the chair.

The Corresponding Secretary read the following letters: from the Scientific Alliance of New York, requesting the co-operation of the Academy in the endeavor to obtain a reduction of postage rates on natural history specimens; from the Royal Society of New South Wales, offering its medal and twenty-five pounds for the best communication containing the results of original researches on a series of specified topics; from the Imperial Russian Geographical Society, enclosing a copy of a pamphlet "Respecting the Necessity of an International Agreement with regard to the Publication of Material contained in Naval Meteorological Journals, a Memorandum drawn up by Rear Admiral Makaroff, St. Petersburg," and

requesting the Academy to favor the Society with its views thereon; from the Royal Academy of Sciences of Turin, announcing the deaths of Commanders Frebretti and Lessona; and from H. von Holst, John Donnell Smith, and Ingram Bywater, acknowledging their election into the Academy.

The chair announced the death of Josiah Parsons Cooke, President of the Academy; of Oliver Wendell Holmes and Edward J. Lowell, Resident Fellows; of E. G. Robinson and W. D. Whitney, Associate Fellows, and of H. L. F. von Helmholtz, a Foreign Honorary Member.

The vacancy occasioned by the death of the President, Josiah Parsons Cooke, was filled by the unanimous election of

ALEXANDER AGASSIZ, *President.*

On motion of the Corresponding Secretary, it was

Voted, That the December meeting be devoted to addresses in memory of the late President of the Academy, Josiah Parsons Cooke.

Voted, To appropriate the sum of two hundred dollars ($200) from the income of the C. M. Warren Fund to Francis C. Phillips, of Allegheny, Pennsylvania, in aid of his researches relating to the Chemistry of Natural Gas; and six hundred dollars ($600) to Charles F. Mabery, of Cleveland, Ohio, in aid of his investigations of the Sulphur Petroleums.

The following report was adopted: —

The Committee, appointed at the Annual Meeting to consider the changes in the Statutes proposed by S. H. Scudder, and the amendment offered by H. P. Bowditch to the rule for the nomination of officers of the Academy, recommends the following alterations in the Statutes: —

Chapter II., Section 1, change the words "a Vice-President" to "three Vice-Presidents, one for each Class." Change the words "written votes" to "ballot."

Section 2, change the word "Vice-President" to "the three Vice-Presidents."

Section 3, add at the end, "or at a meeting called for this purpose."

After Chapter II. insert a new Chapter III., "Of Nominations of Officers," and alter the numbers of the following chapters to correspond to this change. The new chapter to read as follows: —

"CHAPTER III. — OF NOMINATIONS OF OFFICERS.

"1. At the stated meeting in March the President shall appoint from the next retiring Councillors a Nominating Committee of three Fellows, one for each Class.

"2. It shall be the duty of this Nominating Committee to prepare a list of candidates for the offices of President, Vice-Presidents, Corresponding Secretary, Recording Secretary, Treasurer, Librarian, Councillors, and the Standing Committees which are chosen by ballot; and to cause this list to be sent by mail to all the Resident Fellows of the Academy not later than four weeks before the Annual Meeting.

"3. Independent nominations for any office, signed by at least five Resident Fellows and received by the Recording Secretary not less than ten days before the Annual Meeting, shall be inserted in the call for the Annual Meeting, which shall then be issued not later than one week before that meeting.

"4. The Recording Secretary shall prepare for use in voting at the Annual Meeting a ballot containing the names of all persons nominated for office under the provisions given above.

"5. When an office is to be filled at any other time than at the Annual Meeting, the President shall appoint a Nominating Committee, in accordance with the provisions of Section 1, which shall announce its nomination in the manner prescribed in Section 2 at least two weeks before the time of election. Independent nominations, signed by at least five Resident Fellows, and received by the Recording Secretary not later than one week before the meeting for election, shall be inserted in the call for that meeting."

Chapter III. of the present Statutes, Section 1, change the word "Vice-President" to "Senior Vice-President present," and insert at the end of the section, "Length of continuous membership in the Academy shall determine the seniority of the Vice-Presidents."

C. L. JACKSON,
S. H. SCUDDER,
F. W. PUTNAM,
Committee.

The following report was presented and adopted: —

Report of the Committee to consider the Circular of the Royal Society in regard to a Catalogue of Scientific Publications.

The Committee finds itself fully in sympathy with the desire of the Royal Society to improve the methods of cataloguing scientific

literature, and is distinctly of the opinion that the establishment of such a catalogue, to be compiled through international co-operation, is both desirable and practicable.

It seems probable that this improvement in the methods of cataloguing may best be made by establishing some form of card catalogue prepared by the co-operation of a central bureau with the various publishers and editors of scientific literature in issuing with each book and with each number of every periodical a set of cards of standard size and type, each card to exhibit for a book or for a single article in a periodical, —

1st. The name of the author.

2d. The title of the book or article.

3d. The date, place and house of publication of the book, or the title, volume, and page of the periodical, in which the article appears.

4th. A brief statement, not to exceed eight or ten lines, to be prepared by the author himself, setting forth the general purport of the book or article so as to furnish the necessary data for cross references.

Such cards should be in duplicate, to permit of arrangement according to subject or author, or both if desired, and additional cards should be issued whenever the character of the title necessitates cross references.

If thought desirable the type used in printing the cards could be kept set up till the end of the year, and then, by arranging the material according to subjects, an annual report in book form could readily be published.

A central bureau charged with the work as above outlined could very properly be established under the auspices of the Royal Society. In this central office subscriptions could be received from libraries and individuals for cards relating to the articles published in certain journals, or to the literature of certain departments of science, and a subscriber would thus receive, in weekly instalments, a complete card catalogue of all the literature in his own line of work.

The Committee present only a general outline of the plan for this card catalogue, as it is understood that the details of the scheme will be sent to the Committee of the Royal Society by Harvard University. They would further express the hope that some plan may be successfully inaugurated at an earlier date than the year 1900, as suggested in the circular of the Royal Society.

In accordance with the views above set forth the Committee respectfully recommends to the American Academy the adoption of the following votes: —

1. That, in the opinion of the American Academy of Arts and Sciences, the establishment of a catalogue of scientific literature to be maintained through international co-operation is both desirable and practicable.

2. That a copy of this report be transmitted to the Royal Society, as a suggestion of the way in which this plan may be best carried out.

3. That in case such a card catalogue as that recommended in this report be established, it is desirable that the American Academy co-operate with the central bureau by forwarding titles and summaries of the articles published in its Proceedings and Memoirs.

(Signed,)

C. L. JACKSON,
H. P. BOWDITCH,
DENMAN W. ROSS,
Committee.

The Corresponding Secretary read an abstract of C. F. Mabery's paper, "On the Composition of the Ohio and Canadian Petroleums."

The following papers were read by title: —

On the Electric Resistance of certain Poor Conductors. By B. O. Peirce.

On the Variability in the Spores of the Uredo Polypodii. By B. M. Duggar.

Note on the Effect of Temperature on Hysteresis. By Frank A. Laws and Henry E. Warren.

The Recording Secretary presented a copy of the Proceedings of the International Congress on Water Transportation, held at Chicago in 1893, and remarked that it contained a memoir on Electric Haulage which anticipated two papers presented this year at the International Inland Navigation Congress at the Hague, at which he was present.

Eight hundred and sixty-ninth Meeting.

November 23, 1894. — SPECIAL MEETING.

The Academy met at the house of the President, at Cambridge.

The PRESIDENT in the chair.

The death of Robert C. Winthrop, a Resident Fellow, was announced; also, the death of James McCosh, an Associate Fellow.

The President, after acknowledging his indebtedness to the Academy for the high honor conferred upon him by his election, proceeded to give an account of his explorations in 1891 in connection with the U. S. Fish Commission in the Steamer "Albatross," commanded by Captain Z. L. Tanner.

This expedition opened the deep water of the Panamic Region as far west as the Galapagos and as far north as the Gulf of California. He compared the deep water Panamic fauna with the abyssal fauna of the Caribbean, as well as the primal conditions of life existing in the ocean on the two sides of the Isthmus. When contrasting the coral fauna of the two seas he took occasion to refer to his recent explorations of the coral reefs of the Bahamas and of the Bermudas, and to indicate their bearing on the Darwinian theory of the formation of coral reefs. The exploration of the Bahamas took place in the spring of 1893, in the Steam Yacht "Wild Duck," owned by the Hon. John M. Forbes. That of the Bermudas was made in March, 1894.

Morrill Wyman read a paper entitled, "Experiments and Observations on the Summer Ventilation and Cooling of Hospitals."

The following papers were presented by title: —

Contributions from the Gray Herbarium of Harvard University. New Series, No. 9: A Revision of the North American Cruciferæ. By S. Watson and B. L. Robinson.

Experiments on the Relation of Hysteresis to Temperature. By Frank A. Laws and Henry E. Warren.

Notes on Laboulbeniaceæ, with Descriptions of New Species. By Roland Thaxter.

Eight hundred and seventieth Meeting.

December 12, 1894.

The PRESIDENT in the chair.

The President announced the death of Ferdinand Marie de Lesseps, Foreign Honorary Member.

On the recommendation of the Council, it was

Voted, That the use of the Academy's room be granted to the Colonial Society of Massachusetts on the third Wednesday afternoon of each of the five months December to April, in the same way as during the past year.

The meeting was devoted to a commemoration of the late Josiah Parsons Cooke, President of the Academy.

ADDRESS OF CHARLES LORING JACKSON.

JOSIAH PARSONS COOKE, for forty-one years a Resident Fellow of the Academy, Librarian for eight years, Corresponding Secretary from 1873 till 1892, and President in 1892, 1893, and 1894, was born in Boston on October 12, 1827, and died in Newport on September 3, 1894.

He was descended from Major Aaron Cooke, who came in 1630 to Dorchester, Massachusetts, from England, and afterward was one of the founders of Northampton, where he died in 1690. His son, also named Aaron, lived in Hadley, and it was under his protection that the regicides Goffe and Whalley lay in hiding in that town. Noah Cooke, the fifth in descent from Major Aaron Cooke, after serving as a chaplain in the war of the Revolution, moved to New Hampshire, where a son, Josiah Parsons Cooke, the father of the subject of this memoir, was born, in 1787. After a boyhood passed in Keene he graduated from Dartmouth College in 1807, and then established himself in Boston as a lawyer, where, in 1826, he married Mary Pratt, the eldest daughter of John Pratt, a well known merchant.

On October 12, 1827, a son was born, who was named Josiah Parsons Cooke after his father. In 1833 Mrs. Cooke died in Santa Cruz, and her little son, only six years old, and a younger sister, now Mrs. Bennett Hubbard Nash, were left to the devoted care of a faithful friend, who did all that was possible to replace the mother whom they had lost.

Young Cooke grew up a quiet boy, little given to sports out of doors, especially as early in his boyhood a course of lectures given in Boston by the elder Silliman kindled in him an enthusiasm for chemistry, which continued to blaze till the end of his life, and led him to pass all his spare time, not on the playground, but in a little laboratory which he had fitted up in his father's house. Here he attacked the science by experiment, guided by the bulky volume of Turner's Chemistry, and secured a mastery of the subject which would have been highly creditable with a good instructor, but without a teacher of any sort was most surprising. Yet, while a remarkably able student in chemistry and also in mathematics, he had neither taste nor aptitude for the dead languages, and it was only with much difficulty that he surmounted the barrier of Greek and Latin which guarded the approach to Harvard College.

Once fairly in College he distinguished himself in mathematics, but found little instruction in his favorite science. Professor Webster, then near the end of his service, gave the class two or three chemical lectures, which were brought to a sudden end by his show experiment called the volcano, — a large heap of sugar and potassic chlorate piled on a slab of soapstone. After he had lighted it with a drop of sulphuric acid, he saved himself by dodging out of the room, and in a very few seconds all the members of the class found themselves obliged to jump out of the windows. Later, Professor Horsford, who had just taken charge of the laboratory of the Lawrence Scientific School, to fill the gap gave a voluntary course of lectures on chemistry, which, however, did not extend beyond three, so that the teaching of chemistry which he received in Harvard College did not perceptibly add to his knowledge of the science acquired by his own exertions.

After his graduation, in 1848, a year was spent in European travel, and on his return, in the autumn of 1849, he was made Tutor in Mathematics at Harvard College; but the absence of all chemical teaching in the College soon gave him more congenial occupation, since a few weeks after his appointment he was asked to give instruction in chemistry to the Freshmen, and in the following spring (May 25 1850) was appointed Instructor in Chemistry and Mineralogy, with the following condition, — "he providing at his own charge the consumable materials necessary in performing chemical experiments." In this one does not know which to admire more, the liberality of the arrangement or the elegance of the language. The materials to be provided by him need not have been confined to those "consumable,"

however, since the College possessed no apparatus worth mentioning, and his two courses of lectures given in 1850 were illustrated by material brought from the small private laboratory which he had fitted up at home when a boy.

At the end of this year it was decided to fill the Erving Professorship of Chemistry and Mineralogy, and the two most prominent candidates were Cooke and David A. Wells, the first graduate in chemistry of the Lawrence Scientific School, now so eminent for his work in political economy. The election resulted in the choice of Cooke on December 30, 1850, and he held this position till his death. He was now only twenty-three years old, with barely a year and a half of experience as a teacher, and a knowledge of chemistry the product of his own studies unaided by any systematic instruction. With this meagre outfit he was confronted with problems which would have tasked the abilities of an old, experienced, and fully educated professor. The chemical teaching in Harvard College had become extinct, he must re-establish it. The College was wedded to methods of teaching excellent for classics and mathematics, but entirely unfit for a subject like chemistry; he must displace these, and put in their stead better methods, many of which were still to be invented. Finally, he must help to raise science from its position as an unwelcome interloper on the outskirts of the College course to an equality with the humanities intrenched behind centuries of tradition.

His first step after his appointment was to obtain leave of absence for the remainder of the College year, which was well spent in Europe buying apparatus and chemicals, mostly at his own expense, according to an agreement between the Professors of the Medical School; but he also found time to improve his intellectual equipment by attending the lectures of Regnault and Dumas, whose influence can be traced in his strong leaning to chemical physics, and the care and accuracy of his later work upon atomic weights. Regnault especially inspired him with the warmest affection, as is pleasantly shown by the enthusiastic reverence with which he is invariably mentioned in his book on Chemical Physics. With this work his systematic instruction in chemistry, if it can be called such, began and ended, and it is hard to believe in view of his achievements that it was all crowded into six months, broken by many other necessary occupations.

On his return from Europe in 1851 he promptly accomplished his first task, the re-establishment of chemical instruction in Harvard College on its old recitation basis; but it is a high tribute to his

penetration and judgment that he recognized from the first the insufficiency of this way of teaching, and turned eagerly to the laboratory method, invented by Liebig not many years before, and brought to the Laboratory of the Lawrence Scientific School by Horsford, a pupil of Liebig, in 1847. The reason for this, Cooke tells us, was that he had taught himself chemistry by experiment. His second great task, the introduction of this laboratory method, proved no easy one. A beginning was made even in his first year of service as Erving Professor by fitting up a small laboratory in the north end of the cellar of University Hall, under the lecture and apparatus rooms assigned to the Chemical Department. Here Storer, Eliot, Dean, just home from Wöhler's laboratory, and many others, worked as volunteers, but it took seven years of hard fighting to get this course adopted by the College as anything but an extra. Meanwhile he was striving to improve the regular courses by introducing into the two weekly recitations Stöckhardt's Chemistry as the text-book, since this made a first though crude attempt to follow the experimental method of presenting the subject, and by laying great stress on writing reactions, which, to use his own words, "served its purpose in making the study respected in a literary community; but it did this at the sacrifice of all that is distinctive and peculiarly valuable in the study of an experimental science." This led to the publication of his first book, in 1857, which was a thin volume called "Chemical Problems and Reactions," an admirable manual of tactics for this recitation drill. Amid this arid desert of recitations the weekly lecture was the one green spot, as here experimental demonstrations were not only allowed, but required, and yet these lectures were surrounded by difficulties before which most men would have given up in despair. The apparatus which he had brought home from Europe was bought for the Medical School; but, as the College had no chemical collection, it was obliged to do double duty, and the frequent transportation from Cambridge to Boston and from Boston to Cambridge of these bulky and fragile pieces of apparatus used up much time and energy, and must have been a constant strain upon his nerves.

His duties at the Medical School, which at first divided his time with the College, were irksome in the extreme. Chemistry was systematically neglected by the students, and the fact that he held no medical degree caused a certain amount of friction with his colleagues, but nothing could damp his youthful enthusiasm, and laboratory courses in qualitative analysis and medical chemistry were established

by him, although tolerated in the School only as extras. It was at this time that he prepared and delivered a long course of lectures on organic chemistry to satisfy a wholly unintelligent demand on the part of the medical students, to which he alludes later as a monument of useless labor; but this was not the case, as the familiarity thus gained with a field so different from that which he cultivated in after life had a most excellent effect in broadening his view of the science. It was a great relief to him when, in 1857, he was freed from his duties at the Medical School, the apparatus made its last journey over the bridge, and henceforward he was able to devote his time and energy to the development of the chemical department of Harvard College.

But it must not be inferred that during these early years all his attention was given to teaching, as his first scientific paper, that on the Classification of the Elements, dates from this period, since it was published in 1854. It created a marked sensation when, in December, 1853, he presented it to our Academy, to which he had been elected in the previous year. Benjamin Peirce in particular hailed it as a wonderful discovery, and this, as Cooke once told me, had a bad effect on his subsequent work for many years, both by keeping him from many excellent researches because they did not promise far-reaching theoretical results, and by making him try to find such results in all the work that he did. These tendencies unfortunately were not counteracted by association with other chemists, for, although he had many scientific acquaintances, he was singularly unwilling to discuss chemical subjects with them, owing, it would seem, to a natural sensitiveness and reticence inherited from his father, and not modified by study in one of the large foreign laboratories, where a man learns among other useful lessons that all scientific men are comrades. It took him twenty years to shake off this habit of mind, and to grow into a better and therefore more prolific mood in reference to research.

The year 1858 was a most important epoch in his life, as at this time the proper method of chemical instruction was recognized by the acceptance of the experimental course in qualitative analysis as a regular elective study in the College, and also satisfactory laboratory accommodations were provided by the erection of Boylston Hall.

In the ten years that followed no new courses were added, but that already established was perfected, and its success gradually accustomed the College authorities to the new method of instruction, and prepared them for the further advance at the end of this period. But although these years from 1858 to 1868 show no striking changes in the curriculum or very important papers, they are rich in literary

activity. His first large book, the "Elements of Chemical Physics," was published in 1860, an excellent account of this branch of the science as it existed at that day, which ran through three editions, and was still used at Oxford within a very few years. At the very end of this period his second important text-book appeared, the "Chemical Philosophy," published in 1868 (four editions), a wonderfully clear and complete exposition of the modern theories of chemistry. Neither of these books was popular with the students. They could not be, as they obliged their readers to think, and there is no occupation more distasteful to the undergraduate. I can well remember the utter despair which settled upon me when I attacked my first problem in the Chemical Physics. I had never been called upon to think unassisted before, and at first I doubted the possibility of the process. But in this very demand on the thinking powers of the student lay the chief usefulness of these books, and their educational value on this account can hardly be overestimated. Nor would the fact that this work was distasteful have troubled him much, as he often expressed his disapprobation of the sugar-coating now so generally considered essential on educational pills.

A book of an entirely different sort came out between the two which I have just mentioned. This was "Religion and Chemistry, or Proofs of God's Plan in the Atmosphere and its Elements" (1864, and a new edition in 1880). It consisted of a course of lectures delivered before the Brooklyn Institute, the Lowell Institute of Boston, and the Mechanics' Association of Lowell, in 1861. In it the argument of natural theology is worked out in great detail from chemical data, and his stores of scientific knowledge are brought to the service of his sincere and earnest piety.

In 1860, he married Mary Hinckley Huntington, of Lowell, who survives him. Some years later Oliver W. Huntington and his sister (now Mrs. W. A. Pew, Jr.), a nephew and niece of Mrs. Cooke, became members of his family; and their presence did much to brighten his life, and gave additional objects for his warm affection.

For many years before 1868, the Catalogue had contained the following announcement: "Mineralogy is taught to those who desire to learn it by Professor Cooke." This was associated with a similar announcement about Hebrew, and the number who desired either of these incongruous companions was small. Enough however studied mineralogy to prove to Cooke, "somewhat to his own surprise, that, when made solely a subject for object lessons, the study of determinative mineralogy was an admirable training of the powers of

observation, and therefore a disciplinary study of the highest value." Accordingly a certain amount of mineralogy was crowded into the single chemical elective, and when, in 1868, a second elective was introduced, this was devoted entirely to that subject, leaving all the time of the original course for qualitative analysis.

After this time there was a continual increase in the number of the chemical courses, until, in 1871, the single laboratory of the original building became overcrowded, and new accommodations were secured by adding to Boylston Hall a story, which contained a large laboratory for elementary students. At about the same time the chemical department of the Lawrence Scientific School was merged in that of the College, and all the chemical material was removed from the Scientific School building to Boylston Hall. Cooke had now essentially accomplished the three tasks which confronted him when appointed Erving Professor. Chemical teaching was established in the College; the new methods of instruction had been introduced; and equal rights for science had been gained after a hard struggle in the Faculty, in which Cooke took a prominent part, and showed rare powers as a debater and a strategist. It only remained for him to gather the fruits of the victory.

In 1872 he was elected a member of the National Academy of Sciences. In 1873 he was made Corresponding Secretary of our Academy, and for twenty years after this he managed our correspondence and publications, and to him is due the establishment of an annual volume of the Proceedings.

Of the many courses of popular lectures which he gave at this time, one delivered before the Lowell Institute of Boston was embodied in a book called "The New Chemistry" (1874), containing a clear popular account of the modern chemical theories, which he had already treated in a more technical way in his Chemical Philosophy. This book had a striking success. It ran through five editions in English in four years, and was translated into nearly all the civilized languages of the globe. It still remains one of the best and most readable statements of the theories of chemistry.

In 1876 he was elected an Honorary Member of the London Chemical Society, and a few years later a Member of the Royal Institution.

One of his principal amusements was photography, in which he attained remarkable skill, and not only did he take excellent photographs himself, but he collected an enormous number of photographic slides, and his frequent exhibitions of these to his friends or his classes

were most enjoyable, the beauty of the views being enhanced by his vivid descriptions and comments. His own pleasure in these exhibitions must have been as great as that of his audiences, since he was never tired of giving them, in spite of the very considerable amount of trouble and labor which they involved.

The manifold employments which I have tried to sketch left Cooke little time for original investigation, and this, combined with the too exaggerated conception of the dignity of research which he had formed in early life, as I have already said, prevented him from publishing before 1874 very many or very important papers, if we except his discoveries of minerals in Rockport. All this time, however, his chemical ability and insight were slowly ripening, and in 1874 the harvest began with his paper on the Vermiculites, which was closely followed by his researches on Antimony and on Oxygen, so that from this time till 1889 his scientific production was continuous and important.

This scientific activity did not interfere with his other occupations. During this period the number of chemical electives was increased, new laboratories were fitted up, and the growth of the Mineral Cabinet was incessant. This collection of minerals was an object of such affectionate care to him that no account of his life would be complete without a sketch of its history. Starting in comparative insignificance both in quantity and quality at the time he was made Professor, it grew at first slowly, principally by the collections which he made in vacation excursions, and by occasional purchases, until during one of his earlier journeys to Europe he succeeded in buying the collection of Count Liebener, rich in uncommon minerals from the Tyrol. After this it increased steadily by quiet purchases, often paid for out of his own pocket, until in 1875 it crowded Comparative Anatomy, which originally shared Boylston Hall with Chemistry, into other quarters; but in 1891 Mineralogy in its turn had to yield to Chemistry, which was left in undisputed possession of the whole building. To provide new quarters for the minerals, a division of the University Museum was built largely through his exertions, and here the collection was installed, which in the mean time had risen to be one of the first in the world so far as meteorites are concerned by the addition of the J. Lawrence Smith collection, partly left to the College by its original owner, and partly bought with money raised or subscribed by Professor Cooke. Since then the generous gifts of Mr. J. A. Garland of New York and Dr. W. S. Bigelow of Boston have given the collection a similar commanding position in regard to precious stones.

In 1877 he was made an associate editor of the American Journal of Science, and contributed to it then and afterward several excellent reviews of important papers.

In 1881 he collected a number of his essays and addresses in an interesting little volume entitled "Scientific Culture and other Essays." The address which gives its name to the book, and the two which follow, "The Nobility of Knowledge," and "The Elementary Teaching of Physical Science," display the penetrating insight and good judgment which he brought to bear on the problems of education; they are full of wise advice and inspiration. The book also contains appreciative biographical notices of Graham and W. H. Miller, and a paper on the radiometer, dwelling on the scientific principles brought out by this instrument. The careful and enthusiastic study of the radiometer, which led to this article, is exceedingly characteristic of the man. Whenever a striking new discovery was announced, he at once threw himself into the study of it with the greatest ardor. Thus he was probably the first to take calotypes in America, and later became an expert photographer, as I have already said. Shortly after Bunsen and Kirchhoff's great invention, he constructed the most powerful spectroscope of that time, inventing many ingenious contrivances for making the necessary adjustments; several of his papers owe their origin to this work on spectrum analysis, and he was on the point of making a discovery of the first order, the method of seeing the solar prominences in spite of the full glare of the sun, when he was anticipated by two other observers. In the same way he mastered the new science of electrical measurements, procured the necessary apparatus, gave instruction in this subject to voluntary students, and wrote a popular account of its principles.

In 1880 his father died, at a great age, and in the following year, after the graduation of his nephew O. W. Huntington from Harvard College, he went to Europe with his family, and passed the winter in Egypt. This was the last and longest of his many foreign journeys, and was rendered more noteworthy by the fact that on his return to England in the summer of 1882 the University of Cambridge conferred on him the honorary degree of Doctor of Laws.

In 1887 he returned to the field of Natural Theology in a course of lectures before the Union Theological Seminary of New York, which was repeated before the Lowell Institute of Boston, and published in 1888 under the title, "The Credentials of Science the Warrant of Faith." This book, which has passed through two editions, was intended for students of divinity, and the argument therefore is

more technical than that in "Religion and Chemistry." It consists in proving the thesis "that the inductions of natural theology are as legitimate as the inductions of physical science." The illustrations are drawn from astronomy and physics quite as often as from chemistry, and the strong metaphysical bent of his mind is very apparent. Like all of his books which are not text-books, this one shows that he was a devoted and appreciative student of Tennyson, "in whose verses," he says, "he has discovered a truer appreciation of the difficulties which beset" the relation of science and religion "than he has ever found in the philosophy of the schools."

In 1889 he received the degree of Doctor of Laws from Harvard University; and now began the melancholy period when failing health interfered with, though it could not stop, his various activity and wonderful industry. Through it all he was supported by the devoted help and affection of his wife's nephew, O. W. Huntington, who, as he often said, was in every respect the staff of his old age.

A severe functional trouble, which would have thrown most men into retirement, and a serious affection of his eyes resulting in the loss of one of them, were unable to overcome his persistent energy. It is true that he was obliged gradually to abandon his own original work, but he still directed that of a few advanced students, and gave several courses of instruction, including the lectures on general chemistry, to the whole Freshman Class, a labor which would tax severely the powers of a young and sound man. These lectures had continued, with only occasional breaks of not more than two years at a time, ever since he began teaching chemistry in 1850. In the latter years of his life they ceased to be a systematic course in chemistry, and became rather an inspiring statement of the methods, aims, and needs of the science, thus admirably serving their purpose by awakening an enthusiasm for scientific work among the students in their first year. The attendance on these later lectures was voluntary, and it was astonishing to see the crowd packed in the aisles of the old lecture-room, filling the vacant space before the table, and even extending well out into the entry, often with men standing on the stair-rail, and peering over the heads of those in front. As a college lecturer his style was striking and luminous, and his experiments uniformly successful, in spite of his tremulous hand, which one would have thought must have precluded any delicate manipulations. He has enriched the stock of lecture apparatus with many excellent contrivances, notably his arrangement for the projection of spectra, his form of the lecture-table eudiometer, and his vertical lantern. In the

laboratory his explanations were clear and patient, and he always bore in mind the necessity of making the student think for himself. His students, whether elementary or advanced, regarded him with a warm affection, which was well merited by his exceeding kindliness, and his devotion to their interests.

In addition to these labors as a teacher he continued to serve as Director of the Laboratory, and even published an eighth book, "Laboratory Practice" (1891), a series of experiments to be used in fitting students for Harvard College, and in the corresponding College elective study, a course which he had founded, and in which he took till the end the strongest interest.

In 1892 he was elected President of our Academy, but in spite of a journey to Alaska, which gave him much needed change and recreation, he did not survive long to enjoy this well deserved honor. In the summer of 1894, after a most harassing winter, he went to his country house in Newport, where he had passed the summers for more than twenty years, and as soon as the strain of the term's work was removed broke down almost completely. Nevertheless, he managed to make out the European order for laboratory material for the following year in the midst of pitiable weakness, and then slowly, but without pause, faded away, until he died, on September 3, 1894.

ADDRESS OF HENRY BARKER HILL.

The scientific work of Professor Cooke began soon after his appointment to the Erving Professorship, and continued throughout his life. At first he seems to have been drawn toward subjects which were more or less intimately connected with mineralogy, his favorite pursuit, but in later years he turned to problems which tax to the utmost the patience and ingenuity of the investigator, and devoted the last half of his scientific life to the determination of atomic weights.

Forty one years ago, in December, 1853, he presented to the Academy a preliminary sketch of an investigation into the numerical relation of the atomic weights, and the Memoir upon this subject which appeared a few months later is noteworthy in that it was one of the early attempts to classify the elements through their atomic weights. It is, however, to us especially interesting in that it contained a discussion of the errors involved in the determination of atomic weights, which in a way foreshadows the investigations which occupied him in after life. The conclusions which he reached in this

early paper Professor Cooke was able to quote thirty years later as the expression of his riper judgment.

An investigation upon the alloys of zinc and antimony, which followed soon after, in 1854, proved the existence of two definite crystalline compounds of the two metals. A subsequent study showed that the crystalline form of these bodies remained constant with a tolerably wide variation in percentage composition. This fact led him at the time to suggest that perturbation of the law of definite proportion could be effected by mass, and that these perturbations became serious wherever chemical affinity was weak. Six years later he applied the same course of reasoning to the composition of minerals, and came to the conclusion that the general formula in this case was but the typical formula toward which the mineral tended, but which perhaps was never realized with any actual specimen. Twenty-five years afterwards, when Butlerow again discussed the possible variability of the law of definite proportion, Professor Cooke, after referring to his own earlier views upon the subject, wrote that he felt the weight of evidence to be in favor of the atomic theory, and that absolute definiteness of combining proportion which this theory involves.

In 1860 appeared the detailed account of the brilliant researches of Kirchhoff and Bunsen upon spectrum analysis; and with characteristic enthusiasm Professor Cooke was soon absorbed in the study of this new mode of chemical investigation. Several papers appeared upon the construction of spectroscopes, the projection of the spectra of the metals, and upon the aqueous lines of the solar spectrum. While thus engaged in the study of the spectroscope, he found time to make a crystallographic examination of the acid tartrates of caesium and rubidium and of childrenite, and to investigate the dimorphism of arsenic, antimony, and zinc. The results of these investigations were published from time to time in the American Journal of Science.

For several successive years he was now engaged in the study of new mineral species. In 1866 he described danalite from Rockport, Massachusetts, and in the following year cryophyllite from the same locality. He also described at this time two analytical processes which had evidently been suggested by his work upon these minerals. A few years later appeared a paper upon the vermiculites, in which two new species or varieties, hallite and culsageeite, were described, and this was supplemented in the following year by an account of the investigation, with F. A. Gooch, of two more varieties of the same family. These researches, together with a note upon melanosiderite and a crystallographic study of some American chlorites, were the last of his purely mineralogical contributions.

Before the publication of these papers upon the vermiculites, Professor Cooke had begun the study of antimony, and was able to present to the Academy, in June, 1873, a preliminary notice of some determinations of its atomic weight. So many difficulties were encountered, however, that the extended paper upon the subject did not make its appearance until four years later. In 1854 he had expressed the opinion that the accidental errors affecting such determinations could easily be eliminated, while the constant errors were the great errors involved. In 1877 he closes the account of his revision of the atomic weight of antimony with the remark that the investigation from the first had been a study of constant errors. It is not possible to tell briefly the story of the persevering search for these constant errors, — a search involving months of patient labor. I could but repeat the words with which Professor Cooke has himself described, with painstaking fidelity, the steps which he took in surmounting the successive difficulties. The hardest task, possibly, was to show the constant error which vitiated the results obtained by Dumas twenty years before, — results which had been wellnigh universally accepted.

The careful study of the compounds of antimony with the halogens, which was a necessary preliminary to the determination of its atomic weight, established many interesting facts, the most important of which, possibly, was the existence of three different crystalline forms of antimonious iodide belonging, respectively, to the monoclinic, orthorhombic, and hexagonal systems. The results of the quantitative study of antimonious bromide, confirming the value of the atomic weight of antimony which he had previously established, were given in a paper which appeared a year or two later, and the advantage which could be gained by the simultaneous determination of three atomic ratios was here discussed. The evidence was now complete, and the new atomic weight of antimony was adopted by the whole chemical world. A series of less important papers appeared during the progress of this work upon antimony, describing new methods devised for the work, or discussing details of the processes involved. Among them may be mentioned "A new method for manipulating hydric sulphide," "The process of reverse filtering," "Argento antimonious tartrate," and "The solubility of chloride of silver in water."

Shortly after the completion of the work upon antimony, Professor Cooke planned an investigation upon the relative values of the atomic weights of oxygen and hydrogen. The necessary exploratory work upon this research was delayed by failing sight and precarious health, so that it was not until the autumn of 1886 that everything was ready

for the final decisive experiments. During the following winter, with the co-operation of T. W. Richards, numerous determinations were made, in which an accurately weighed quantity of hydrogen was burned, and the weight of water which was formed determined. The experimental difficulties involved were great although they were in kind quite different from those which the work upon antimony presented. These difficulties were at last overcome, and the wonderfully close agreement between sixteen successive determinations, made with hydrogen prepared in three different ways, showed how perfectly all sources of accidental error had been eliminated.

One source of constant error had been overlooked, however, which affected not only these determinations but all the results which had ever been obtained by the classic method of Regnault. Agamennone, and afterward Lord Rayleigh, discovered that the volume of a glass vessel was sensibly diminished when the air within it was exhausted, so that the tare of the globe in which the hydrogen had been weighed had been incorrectly determined on account of the diminished volume of the air displaced. The amount of this error could easily be determined, and in a second paper the necessary small correction was applied. In order to avoid this change of volume, he devised an ingenious method for determining the tare of the globe without exhausting it; and this method was the subject of his last communication to the Academy, in June, 1889.

As an investigator Professor Cooke was clear in thought, persevering amid difficulties, fertile in expedients, impatient of dogma, and to the end he retained the keen curiosity and enthusiasm of his earlier days.

ADDRESS OF AUGUSTUS LOWELL.

It is always interesting to trace the impulse which had determined a man's life work. It is peculiarly so to me in the case of Professor Cooke, because he himself was wont to attribute it in a large measure to the impression made upon him as a boy by the lectures of Professor Silliman, before the Lowell Institute. These lectures opened a new horizon. He was intensely interested, repeating the experiments he had witnessed with such imperfect appliances as he was able to procure, and from that moment there was no hesitation as to his future. His life was to be devoted to the study of Chemistry.

There was nothing in his birth or surroundings to indicate such a career. His father was a successful lawyer; his maternal ancestors

devoted to commerce. The pursuit of Science for its own sake was little understood or appreciated. There was no adequate teaching, and those of us who can remember the lectures in Holden Chapel will realize what must have been the difficulties of a young beginner.

When the College lost its Professor of Chemistry, it was not easy to fill the position. The same necessity which had called a young Divinity student to the Professorship of Physics, placed an untried youth in the chair of Chemistry. The choice was justified, however, by the result.

To a keen mind and power of analysis Cooke added a gift of language and clearness of statement which made him a natural lecturer. It was said of him that he recalled the manner of Faraday; and whether he was explaining the mysteries of Science, describing the recently discovered Pharaohs, or treating of the higher issues of religious thought, the same charm marked his discourse. With uncertain muscles which often seemed to imperil the success of an experiment, there was no hesitancy in thought or utterance. All was clear, logical, and convincing. I never had the opportunity of hearing him at Cambridge, but I have often listened to his public lectures, and can bear witness that few lecturers held the attention of their audiences more completely than he, or gave more pleasure.

Professor Cooke did not confine himself to one subject of thought. He was many-sided. His religious lectures were marked by the same cogency of reasoning, purity of style, and apt illustration as any of his scientific discourses.

Professor Cooke lectured eight times before the Lowell Institute, and I cannot better indicate the breadth of his studies than by enumerating the subjects of these lectures.

In 1855 and 1856 he lectured on "The Chemistry of the Non-metallic Elements."

In 1860 and 1861, on "The Chemistry of the Atmosphere as illustrating the Wisdom, Power, and Goodness of God."

In 1864 and 1865, on "The Sunbeam, its Nature and Power."

In 1868 and 1869, on "Electricity."

In 1872 and 1873, on "The New Chemistry."

In 1878 and 1879, on "Crystals, and their Optical Relations."

In 1887 and 1888, on "The necessary Limitation of Scientific Thought."

In 1892 and 1893, on "Photographic Sketches of Egypt."

This last course recalled his travels and embodied the study and reflections of a cultivated mind amidst the monuments of that wonder-

ful country. To it he brought the same patient investigation and broad generalization which marked his work elsewhere, and his treatment of it before his audience was generous, persuasive, and attractive.

One word I may be permitted in regard to his personal qualities. Professor Cooke was eminently simple, truthful, and earnest, kindly and affectionate. Possibly my connection with the Institute, which had done so much to determine his career and before which he had so often appeared, may have influenced his feeling, but to me he was always a kind friend, for whose attainments I had the highest respect, and whose pure, honest, confiding nature was always attractive and inspiring.

ADDRESS OF FRANCIS HUMPHREYS STORER.

I HAVE heard Professor Cooke say jokingly, but with a tinge of honest pride, that he was a "self-made chemist." The remark was true in one sense, for beside listening as a boy to a few popular lectures by the elder Silliman, and following for a brief period some of the public lectures of Dumas and other Parisians, he never had any definite, stated instruction in Chemistry. To the best of my knowledge and belief, he never worked for an hour in any other laboratory than his own. Many of the most familiar details of analytical manipulation he learned from his assistants while teaching them and his classes what Chemistry really is. It was from books and from his own inner consciousness that chemical knowledge came to him. Yet, thanks to native ability, to an excellent academic training, to inherited wealth, a clear head and a tenacious will, he came at last to stand in the fore-front of American chemists, and to command the attention of the fraternity in every land. Even as a manipulator, he became expert; in spite of a constitutional tremulousness, which, in his youth at least, had placed him at a great disadvantage. Like the surgeon with his knife, in the story, he had so mastered his trembling hand, that the thing held in it should shake assuredly into the right place.

But, although it is fair enough to say that as a chemist Cooke was self-taught, no such statement would be true of him as a scholar. There can, I think, be no question that a great part of the strength of the man depended upon a scholarship distinctly superior to that of most contemporaneous chemists. In point of fact, Professor Cooke was very carefully trained at College, where he came under the influence of many eminent men. Thanks to the teachings of Benja-

min Peirce and Joseph Lovering, he became accomplished in the mathematics and in physics. Doctor Beck taught him Latin enough for his purposes. Felton and Sophocles strove with him as to Greek, and with Doctor Walker his relations were peculiarly intimate. He long continued to look up to President Walker as to a counsellor and guide. In the matter of rhetoric, he had the inestimable advantage of Professor Channing's drill. He was in contact also, to a certain extent, with such teachers as Asa Gray, Jeffries Wyman, and Longfellow. Incidentally, he obtained a good working knowledge of French and German.

It was by his mathematical studies more particularly that Cooke acquired that habit of thinking clearly and reasoning closely which distinguished him through life. To his academic training I attribute also much of that power of stating his thoughts clearly and forcibly, which made him one of the best teachers of his time. No matter what objection a purely literary person may be moved to urge against the use of the word "scholarship" as here applied, or what criticisms may occur to any one as to the style or manner of the man, it will still remain true that Professor Cooke's knowledge was ample and assured. In many respects it was profound! His reasoning was always cogent and his language plain.

I remember well the very favorable impression made by an address which he delivered at the opening of the Harvard Medical School, immediately after his appointment to a chair at that institution. There had been murmurings in the land that one so young and so inexperienced should have received the appointment. But they were silenced then and there, absolutely and forever.

There is, indeed, a certain note of distinction in many of Cooke's writings, such as is all too rare in scientific literature. Several of his memoirs might well be set before the laboratory student as models of clear presentation of a subject, in the same sense that, at an earlier time, we turned for such illustration to the writings of Gay-Lussac and Thénard, of Dumas, Boussingault, and Berzelius.

On looking beyond this immediate locality or centre, it will be seen that there have been thus far, here in America, four great chemical teachers; the elder Silliman, Hare at Philadelphia, Draper in New York, and Cooke at Cambridge; and of these four Cooke undoubtedly deserves to be placed first and foremost, in view of the fact that working and teaching chemists, trained by him, are scattered throughout the land. Were it not for this circumstance, it might perhaps justly be claimed that Draper's name should take precedence, because

of the great influence he exerted during many years as a lecturer, a writer, and an investigator.

After all has been said, however, as to talent innate, power inherited, or wisdom acquired, it must still be remembered of our lamented President that he ranked higher than most men, because of the indisputable fact, that occasionally — at not infrequent times and seasons — his mind was illumined by divine sparks and flashes of genius.

ADDRESS OF CHARLES WILLIAM ELIOT.

LAST spring an inquirer into the Department of Chemistry and Mineralogy in Harvard University would have found a building called Boylston Hall, one hundred and twenty feet by seventy, and three stories in height, completely occupied with the laboratories, store-rooms, and lecture-rooms for Chemistry, and a large section of the University Museum devoted to mineralogical collections and laboratories. Turning to the College Catalogue he would have found a series of elective courses in Chemistry, beginning with General Chemistry and Elementary Mineralogy, and rising through Qualitative Analysis, Quantitative Analysis, Organic Chemistry, Crystallography and the Physics of Crystals, Chemical Physics, and the Philosophy of Chemistry, to original investigation in various branches of both Inorganic and Organic Chemistry. Last year there were three hundred and fifteen choices of these courses made by graduate and undergraduate students; so that this number of places had to be provided in the laboratories of the department. The inquirer would also have seen large illustrative collections of apparatus, chemicals, and minerals, — and particularly the mineral collection would have struck him as extensive, well selected, and valuable. He would have found as teachers in the department three full professors, three instructors, and eight assistants. This elaborate and well equipped department of instruction has grown up in the course of forty-four years under the direction of one man, Josiah Parsons Cooke. I shall endeavor to show in some detail the strenuous, persevering, and well-directed labor by which Professor Cooke developed this admirable instrument of instruction and research. I might simply say in eleven words, — Professor Cooke created the Chemical and Mineralogical Department of Harvard University; but I should like to put before you some faint picture of the intelligence, energy, persistence, and enthusiasm which went into the accomplishment of that task. Mr. Cooke took the degree of Bachelor of Arts in 1848, but when he was an under-

graduate at Harvard no Chemistry was taught there. I have often heard him say that he got his best guidance and incitement towards chemical study from the lectures of Professor Benjamin Silliman, the elder, before the Lowell Institute, in the early days of that invaluable institution. Although he had never received any systematic instruction in either Chemistry or Mineralogy, Mr. Cooke had acquired a considerable knowledge of the elements of both these subjects by 1849, and what is more, he had determined to be a teacher and a man of science. On the 3d of July, 1849, he was appointed Tutor in Mathematics in Harvard College, at the usual salary of $645 a year. Such an appointment seems almost incredible to the present generation, for he cannot be said to have received any professional training in Mathematics. In his view it merely offered an entrance into the Faculty of Harvard College.

On the 24th of November following, "Mr. Tutor Cooke was appointed (by the Corporation) to teach Chemistry to the Freshman Class next term. For this service, and for the apparatus and materials he may use, Mr. Cooke shall be paid $225." Such was the vote of the Corporation. The edge of the wedge was very thin; but it made a sufficient entrance. At the same meeting the Corporation voted, "As instruction in Chemistry for the undergraduates is no longer to be required of the Erving Professor (J. W. Webster), *Voted*, That for the rest of his services his salary be $1,000." Professor Webster's salary from the College (he was Professor also in the Medical School) had previously been $1,200. The Corporation had therefore taken $200 from his salary and given it to Mr. Cooke. It was an extraordinary coincidence that on the day before this ominous vote was passed Dr. Webster had killed Dr. Parkman; and on the 30th of November he was arrested for the crime. . . . During the ensuing term Mr. Cooke gave lectures to the Freshman Class, and held recitations; and then and there I, for one, first learned what Chemistry was about, and what was the scientific method in observing and reasoning.

On the 25th of May, 1850, the Corporation voted, "That Mr. Tutor Cooke, for the ensuing academic year, teach Mathematics to the Freshman Class, and Chemistry to the Sophomore and Freshman Classes, and Mineralogy to the Seniors, and that his salary shall be $1,000, he providing at his own charge the consumable materials necessary in performing chemical experiments." The frugality and prudence of the Corporation appear in these money votes. They had no idea of taking any great risk on the cost of illustrative materials;

but Mr. Cooke was fortunately indifferent on that subject. He had resources which enabled him to provide all necessary furniture, apparatus, and materials; and he used these resources with liberal good sense. He got possession in this first year of the lower northern lecture room in University Hall, and of a room about twenty by twenty-five feet in area in the northwestern corner of the basement of the same hall. There he fitted up the only chemical laboratory on the premises of Harvard College. There was already a good laboratory across Kirkland Street, in the new building of the Lawrence Scientific School; but with that the College had nothing to do. There was neither gas nor running water in University Hall, and Mr. Cooke's nearest neighbor on the adjoining corner of the basement was a baker's oven, where considerable batches of bread were baked every morning and every evening, and yeast was sold every afternoon. A pump in the cellar yielded water for both bakery and laboratory, and within fifty feet of the pump was a privy which served for the whole College.

On the 10th of July, 1850, Professor Webster's resignation was accepted. The young tutor had completed his plans for the ensuing year; but, for some reason which cannot now be determined, he procured a vote of the Corporation to settle one part of his plan. On the 31st of August, 1850, the President and Fellows voted, "That Stöckhardt's Principles of Chemistry be adopted as a text-book in the College." I know of no other instance within the last fifty years in which the President and Fellows have passed a vote concerning the adoption of a text-book.

On the 30th of December, 1850, Mr. Cooke was elected Erving Professor of Chemistry and Mineralogy, at the age of twenty-three. He had already demonstrated to the satisfaction of the Corporation that he was an efficient and prudent manager in business details, an interesting lecturer, and a zealous and singleminded College official. His salary was fixed at $1,200, "he paying all the expenses of his lectures, excepting that of fuel in Cambridge, the salary to commence on the first of March next." Again, a frugal arrangement which did not in the least discourage the youthful professor.

The vote describing his duties is an interesting one, for it illustrates the extraordinary expectation which it was then held reasonable to entertain concerning the teaching capacities of a youth of twenty-three: —

"*Voted*, that he shall reside in Cambridge, and be a member of the College Faculty, and that he shall give the lectures in the Medical College in Boston, and all the instruction required in Chemistry,

Mineralogy, and Geology to the undergraduates, and perform such other duties as may from time to time be assigned him by the Corporation not inconsistent with the duties of the office."

Professor Cooke immediately resigned his Tutorship in Mathematics. He had now obtained the firm position from which he proposed to carry on the long campaign for the introduction of Chemistry and Mineralogy into the teaching of Harvard College. He held a permanent professorship; he was a member of the College Faculty, which his predecessor had never been, and he had established a small chemical laboratory in the middle of the College Yard. He prevailed on the Faculty to announce Chemistry for Freshmen in the second term of the year 1850–51, and Chemistry for Sophomores in the first term of the year 1851–52; also lectures on Mineralogy to Seniors in the first term of 1851–52. The introduction of these new subjects into a prescribed curriculum, which was already overloaded, is a subject for wonder and admiration. The present generation of teachers finds it hard enough to get new elective courses announced; but Professor Cooke successfully invaded a prescribed course in which the traditional subjects had long been securely intrenched.

In the second story of Harvard Hall was a large, miscellaneous, and unassorted collection of minerals and fossils, with some curiosities, which had been accumulating for years, but had received little care. Within a few months of his appointment as professor, Mr. Cooke made a survey of this inchoate collection. His knowledge of minerals was mathematical and physical rather than chemical, and he had no considerable experience in recognizing and determining them. He did not feel competent, without assistance, to sort the collection, and decide what to keep and what to throw away. He feared lest, through ignorance, he might reject valuable specimens; yet the sorting of the collection was obviously the first thing to be done. Under these circumstances he did a conscientious and courageous thing which, in my judgment, very few persons in his situation would have done. He employed Professor Benjamin Silliman, Jr., of Yale College, to sort the collection, and advise him what to keep and what to throw away. Professor Silliman performed this task with promptness and discretion, and the specimens then selected for preservation, — which naturally represented in the main the commoner species — constituted the skeleton, as it were, of the rich and ample collection of to-day. Out of this intercourse between Professor Silliman and Professor Cooke there grew a life-long friendship. The collection remained in Harvard Hall for eight years, being enlarged every year by Professor Cooke's constant activity in buying and collecting.

The Corporation soon found that it was difficult to resist the frequent demands of the young Professor. On the 25th of January, 1851, they granted "$200 to Professor Cooke for purchasing chemical apparatus for the laboratory at Cambridge for the use of the undergraduates." Observe the phrase, "the laboratory at Cambridge." It was still that little room in the basement of University Hall. On November 8th, 1851, by vote of the Corporation, Professor Cooke was "made a member of the Faculty of the Scientific School to teach Mineralogy to such students as may desire his instruction." His membership of the Scientific Faculty was always for Professor Cooke rather a security against the invasion of his precincts, than a means of prosecuting any aggressive campaign on his own part. For ten years there stood a notice in the Catalogue under the head of the Lawrence Scientific School to the effect that Professor Cooke would receive students in Mineralogy at his laboratory during the second term. Then for ten years more an enlarged notice under the same head invited scientific students to attend the course in Crystallography and Mineralogy which he was really providing for College students. In 1871–72, when the Scientific School was reorganized, all special mention of these opportunities was withdrawn.

The very next month — that is, in December, 1851 — the Corporation received a communication from the Erving Professor, "respecting the accommodation at present afforded for the chemical apparatus of the College." This communication was referred to President Sparks and Dr. Walker, two firm friends of Professor Cooke. The result was that he got possession of a room on the first floor of University Hall adjoining his lecture-room; and this room he immediately fitted up at his own expense with counters and other conveniences. He also got rid of the baker and occupied his quarters. On the 31st of January, 1852, the "Treasurer was authorized to discharge the account of Professor Cooke for apparatus in Chemistry and Geology procured by him in Europe for a sum not exceeding $150, in addition to the appropriation heretofore made for that purpose." In the following month they voted "that the Treasurer be authorized to expend a sum not exceeding $120, for the fitting up of the Rumford apparatus room." This was the room of which Professor Cooke had just got possession. In the mean time Professor Cooke had persuaded the Faculty to permit him to give lectures on Mineralogy to Juniors in the second term, and a course of lectures on Chemistry to Sophomores in the first term, — these in addition to the recitations in Stöckhardt's Chemistry in the

second term for Freshmen, and in the first term for Sophomores. This was no inconsiderable amount of teaching for an inexperienced young man who had on his hands also the giving of a course of lectures at the Medical School in Boston, from the 1st of November to the 1st of March. At the building in North Grove Street, where he found plenty of space, and very little else, Professor Cooke fitted up an excellent laboratory for lecture purposes and for research. The Medical Class was turbulent, and always contained a considerable proportion of rough, uneducated young men; but the young professor made his lectures so interesting by carefully prepared experiments, that he rarely had trouble with his boisterous auditors. To the methods and policy of the Medical Faculty, on the other hand, he soon began to manifest a dislike, which before long became acute.

On the 26th of June, 1852, the President and Fellows passed a vote making "an *annual* grant of $200, half for minerals and half for chemical apparatus, to be disbursed under the direction of the Erving Professor, who will account for the same at the end of each academic year." That vote remains in force to this day; but the annual grant has risen from $200 a year to $800. It gave Professor Cooke something on which he could depend every year for the increase of apparatus and of the mineral collection.

In the following November, the Treasurer of the College laid before the Corporation "a catalogue of the Rumford and other apparatus belonging to the College, in charge of the Erving Professor of Chemistry, which had been examined and verified by him and found to be in good order." In less than two years Professor Cooke established his reputation with the Corporation as a trustworthy custodian of apparatus and other College property. This reputation stood him in good stead throughout his career. He had also secured laboratories both in Cambridge and Boston, procured considerable quantities of fittings and apparatus, and pushed his subjects into the prescribed curriculum of the College.

Let us turn now to consider what he did next in the Faculty. In 1852–53, he introduced a course of lectures on Chemistry, twice a week, for Seniors in the second term. He had already got access to the Freshmen, Sophomores, and Juniors. In the following year he gave up the Freshman Chemistry in the second term, in order to occupy both terms of the Sophomore year. The Senior lectures on Mineralogy disappeared, but instead, notice was given that Mineralogy is taught to those who desire to learn it by Professor Cooke. Considering that not a particle of Chemistry was taught to undergradu-

ates, in 1850, he had certainly obtained a good position for his subjects in the College course by 1853. At the beginning of the medical term in the autumn of 1853, he was ready to receive a small number of medical students into his Boston laboratory, to pursue the subject of qualitative analysis, and James C. White, subsequently adjunct Professor of Chemistry in the Medical School, was a member of this first class. It is believed that this was the beginning in the United States of laboratory instruction in Chemistry for medical students.

On the 23d of May, 1855, comes the first application of a method which Professor Cooke afterward used often. The Corporation voted, "That $500 be appropriated to supply deficiencies in the cabinet of minerals, to be expended under the direction of Professor Cooke, provided that the additional sum of $500 be raised by private subscription for the same purpose." Nearly a year later Professor Cooke informs the Corporation that $1470 (subsequently increased to $1720) have been contributed by persons whose names are subjoined for the increase of the mineral cabinet, and he thereupon proposes that he have leave of absence for the summer term of 1857 to make purchases in Europe. In every summer vacation, and in some of the long winter vacations of that period, Professor Cooke travelled in search of minerals; and for a period of six years I frequently accompanied him. I was the first student whom he admitted to the little laboratory in the basement of University Hall, and Professor Frank H. Storer and I were his first assistants, both at the Cambridge laboratory and at the laboratory in the Medical School. I therefore have a vivid recollection of the humbleness of the beginnings of both the Chemical and the Mineralogical departments; of the elementary quality of the instruction given; and of the great disadvantages under which all the instruction was given, without any possibility of offering laboratory practice to the students, except as a favor which could be granted only to very few; but I also have a clear vision of the indomitable industry, perseverance, and mental activity of the young Professor. He threw himself body and soul into his work, and wanted neither recreation nor leisure, neither ease nor pleasure, but only work which would tell for the advancement of his department and the satisfaction of his worthy ambitions.

Early in 1856, he began to revolve plans for building a Chemical Laboratory at Cambridge; but a suggestion made to him by Mr. John Eliot Thayer turned his attention to the Boylston Fund (then amounting to nearly $23,000), which was held by the Corporation

for the purpose of ultimately building an Anatomical Museum and Chemical Laboratory. This fund was to accumulate until it reached the sum of $35,000 ; but Mr. Thayer suggested that the fund be filled up by private subscription and the building contemplated by Mr. Boylston be at once erected. Accordingly, on the 30th of August, 1856, we find this entry in the records of the President and Fellows : "A letter from Professor Cooke having been read, the President, Treasurer, and Dr. Hayward were appointed a Committee to confer with Professors Wyman and Cooke on the subject of an Anatomical Museum and Chemical Laboratory." This project being made known abroad, a storm arose in the Medical Faculty, who feared the competition of the proposed Cambridge establishment. On the 15th of September following "a memorial from the Medical Faculty on the subject of certain proposed subscriptions was read and referred to the same Committee to which the letter of Professor Cooke was referred at the last meeting of this Board."

At a meeting of the President and Fellows on September 27th, "on application of Mr. Cooke, Erving Professor of Chemistry and Mineralogy, *voted*, that the Erving Professor be released from the duty of delivering lectures at the Medical College in Boston." Thereupon Professor Cooke caused all the excellent fixtures and furniture which he had provided in the building on North Grove Street to be torn out, and removed with all his apparatus to Cambridge. This vigorous procedure occurred shortly before the opening of the medical course of lectures, and threatened grave inconvenience to the Medical Faculty. At the same time, Professor Morrill Wyman resigned as a member of the Medical Faculty, because he was charged with disloyalty to the Medical Faculty in promoting the building of Boylston Hall. Altogether, the conflict waxed so warm, that Professor Cooke proposed an adjustment, which was carried into effect. By his advice I gave the first half of the course of chemical lectures at the Medical School, and Professor Cooke lent me, as his friend, all the apparatus and supplies necessary for the purpose. This sudden and unexpected disturbance led to two good results. It freed Professor Cooke from distracting and uncongenial labors at the Medical College; and it caused the appointment of a separate Professor of Chemistry for the Medical School, the first incumbent of that professorship being the excellent Dr. John Bacon, who began his labors in January, 1857. Thereafter, Professor Cooke was entirely free to devote himself to the interests of his departments at Cambridge.

In 1856 — the year now under consideration — Professor Cooke obtained from the College Faculty a really extraordinary concession for the ensuing academic year. He succeeded in introducing into the Junior year a required course on Molecular Physics, the text-book being the first volume of Graham's Elements of Chemistry. When one remembers that the traditional subjects filled well the prescribed curriculum, it is a marvel that a wholly new subject should have been inserted into the Junior year. Two years later the text-book for Molecular Physics became Cooke's Chemical Physics, — a work which showed the natural leaning of his mind to Physics rather than to Chemistry, and which also showed what importance he attached to exactness and thorough drill in undergraduate work. The book was intended to be used with numerous problems of an arithmetical or algebraic sort. The same year which saw the introduction of the Chemical Physics, namely, 1858–59, saw also an additional chemical elective for Juniors, — in the first term, Crystallography, and in the second term Analytical Chemistry and Dana's Mineralogy, — but in the meantime Boylston Hall had been built.

I must turn back for a moment to the year 1856. On the 25th of October, 1856, the Corporation voted, "That the President, Dr. Hayward, and Mr. Lowell, be a Committee to consider and report upon a plan and location for a building for the Anatomical Museum and Chemical Laboratory," and three months later it was voted "That the Committee on the new Anatomical Museum and Laboratory be authorized to make contracts for the erection of the same whenever the subscriptions for the increase of the Boylston Fund shall amount to $17,000." At the same meeting, "it appearing to this Board that in the new distribution of studies for the present year the proportion assigned to the Erving Professor of Chemistry and Mineralogy has been largely increased, so that the work now required of him equals the average of what is required of the other Professors, therefore, *Voted*, That the salary of the Erving Professor of Chemistry and Mineralogy be raised to $2,200, until further order of this Board." This vote, passed only seven years after the election of Mr. Cooke as Erving Professor, established him on terms of perfect equality with the Professors of the traditional subjects in Harvard College; and he was now only thirty years of age.

By the 31st of January, 1857, the necessary supplement to the Boylston Fund had been raised and the contract made for the erection of the building. On the 20th of May following, Professor Cooke reported to the Corporation on the inception and completion of this

undertaking. The sum raised was $14,000. Thereupon it was voted, "That the Corporation avail themselves of this opportunity to express their sense of the efficiency and public spirit of Professor Cooke in obtaining the above mentioned subscriptions, and of his devotion to science and to his own department of instruction in the University, as manifested in his willingness to commence this movement, and in the unwearied efforts by which he has brought it to a successful issue." Long before the building was finished, — namely, on the 29th of August, 1857, "Mr. Lowell laid before the meeting a communication from Professor Cooke in regard to the necessary furniture for the new Anatomical Museum and Chemical Laboratory," whereupon it was voted "That the Building Committee be authorized to contract for the necessary furniture not exceeding the sum of $2,000." On the 1st of January following, the "Building Committee was authorized to pay a further sum, not exceeding $2,108, for altering, finishing, and fitting up the new Museum and Laboratory."

All this time Professor Cooke had had no visible assistance in the conduct of his department. He had himself paid for the services of Francis P. Clary, for many years his only assistant at his lectures, and he had received some volunteered assistance from students. In February, 1858, Charles W. Eliot, Tutor in Mathematics, was elected Assistant Professor in Mathematics and Chemistry, "to give such assistant instruction in the Department of Chemistry as may be agreed upon in the distribution of studies by the Faculty." The duties of this officer continued, however, to be chiefly mathematical, and it was not till January 26, 1861, that the Corporation voted, "That the duties of Mr. Charles W. Eliot be limited to the Chemical Department, and that he be designated accordingly."

On the 26th of June, 1858, a committee of the Corporation having reported that Professor Cooke had given furnaces, counters, and cases which originally belonged to him, and that part of the apparatus still belonged to him, it was voted, "That the President be requested to write a suitable letter of acknowledgment to Professor Cooke for his liberal contributions towards the erection and furnishing of Boylston Hall, and for his zeal and unremitting attention in overseeing the progress and successful accomplishment of the whole work." There are at this moment in Boylston Hall wooden counters and hoods with cast-iron sashes which Professor Cooke caused to be made forty-three years ago for the Laboratory which he first fitted up in the Medical College on North Grove Street. Boylston Hall was originally two stories high, and the western end was devoted to the Anatomical

Department, in charge of Professor Jeffries Wyman. About two thirds of the building, however, were devoted to the Chemical Department.

In 1858–59 the first laboratory instruction in Chemistry open to Harvard undergraduates, was given in Boylston Hall, and in that first class I find the following names, now well known in this community: —

James A. Rumrill,
William Everett,
William R. Huntington,
S. W. Langmaid,
John Homans, Jr.,
Henry P. Walcott, and
Louis Cabot.

The number of students in this first class was twenty-three, part of them graduates.

On the completion of Boylston Hall, the Mineral Cabinet was moved into it, so that all Professor Cooke's interests were concentrated in that building. The completion of Boylston Hall made it possible for Professor Cooke to teach mainly by the laboratory method; but recitations and problem work, not accompanied by laboratory practice, lingered, nevertheless, for seventeen years; although only in required courses. There was a required course in the Junior year down to 1867–68, and in the Sophomore year down to 1872–73. The required work was then moved into the second term of the Freshman year, whence it disappeared in 1875–76, a brilliantly illustrated course of lectures, always given by Professor Cooke, being thereafter the sole remnant of required work in Chemistry. The expansion of the elective work after the completion of Boylston Hall went on as follows: In 1868–69 a Senior elective appears, which was devoted in the first term to Crystallography and the Physics of Crystals, and in the second term to Mineralogy and the Determination of Minerals. In the year 1871–72 there are electives in Chemistry for the Sophomore, Junior, and Senior years, and Organic Chemistry appears in the Senior electives. In 1873–74 the electives are: —

1. Descriptive Chemistry.
2. Qualitative Analysis.
3. Mineralogy.
4. Quantitative Analysis.
5. Organic Chemistry.

In 1876–77, two new electives were added, — namely, an advanced course in Inorganic Chemistry, and a course in Crystallography and the Physics of Crystals, the second of these subjects having appeared for the first time as a half course in 1868–69. In 1886–87 the advanced course in Inorganic Chemistry was more completely defined as including Molecular Weights and Volumes, Thermo-Chemistry, and Specific Refractive Power. This course, thus introduced by Professor Cooke, has to-day a growing importance. In 1892–93, at the age of sixty-five, Professor Cooke undertook a new elective course in Chemical Philosophy and the History of Chemistry. This was the last addition he made to the series of elective courses he had successively introduced, the greater part of which he had delivered over into the hands of younger men. We cannot too much admire the intellectual vitality which enabled him to keep in the van of the onward movement in an extensive department which he had himself filled with younger teachers full of zeal and ambition.

The picture of Professor Cooke's influence at the head of the Chemical Department down to 1880, would be incomplete without an enumeration of the names of the young men who served as his laboratory assistants during the first thirty years that he held the professorship. Three of these gentlemen died young; but the following survive: —

Professor Frank H. Storer,
President Charles W. Eliot,
Professor William H. Pettee, of the University of Michigan,
Professor Charles L. Jackson,
Professor Henry B. Hill,
Professor Charles E. Munroe, of Washington,
Professor William Elder, of Waterville,
Professor Frank A. Gooch, of Yale University,
Professor M. E. Wadsworth, Head of the Michigan Mining School,
Professor Charles F. Mabery, Professor in the Case School of Applied Science of Cleveland;

and four gentlemen who have all been devoted to technical Chemistry, — namely, Messrs. Charles S. Homer, William D. Philbrick, John F. White, and Harry Blake Hodges. All these gentlemen were emphatically Professor Cooke's assistants. A large number of younger men have been trained as assistants in Boylston Hall during the last fourteen years; but many of them were brought into little immediate contact with Professor Cooke, because they served in laboratories

which were chiefly directed by other Professors. Of late years he used to complain that there were assistants in Boylston Hall whose names he did not know, — an inevitable but unwelcome result of the growth of the establishment.

The growth of the College and the increased teaching of Chemistry by the laboratory method, made it necessary in 1871 to enlarge Boylston Hall. This was done by adding a roof story, at a cost of $13,500, of which sum Professor Cooke contributed $1,000 and his father $500. Professor Cooke also devised all the improvements himself, and zealously superintended their execution. For the uses of the Chemical Department, two thirds of the roof story were available; the trustees of the Peabody Museum hired the remaining third. This enlargement of Bolyston Hall made it possible to carry all the chemical teaching at Cambridge to that building, and, therefore, to close the Chemical Laboratory in the Lawrence Scientific School. This change was in part an economical measure, but was due, also, to the desire of the Corporation to use Count Rumford's gift for teaching the subjects of light and heat, and to make the Rumford Professorship again a College professorship. The consolidation was naturally a great satisfaction to Professor Cooke, and it was certainly an important step in the development, not only of the Chemical Department, but of the Department of Physics as well.

After the lamented death of Professor Jeffries Wyman in 1874, Professor Cooke began the process of acquiring for Chemistry the whole of Boylston Hall. The rooms on the lower story of Boylston Hall, which had formerly been used by Professor Wyman, were fitted up for a laboratory of Organic Chemistry. In the summer of 1877 the Peabody Collection was moved from Boylston Hall to the new building erected by the trustees; and thereupon the two large and handsome rooms on the western side of Boylston Hall were appropriated to the Mineral Cabinet, which had long outgrown its narrow quarters. The rearrangement of this collection made manifest the results of Professor Cooke's well directed and unremitting exertions for twenty-six years. The collection had become not only an effective instrument of instruction, but a beautiful and impressive representation of the mineral kingdom, unusually complete, and of large money value. From this date Professor Cooke had possession of the whole of Boylston Hall, except that a lecture room on the western end was still used for miscellaneous purposes. In 1887 this lecture room was converted into a laboratory for elementary experimental Chemistry, — again both planning and executing being Professor Cooke's. His

occupation of the hall thus became complete, twenty-nine years from the date of its erection.

One year later, Professor Cooke entered on his last undertaking for the enlargement of his domain. He began to make plans and solicit subscriptions for a section of the University Museum on Oxford Street to be devoted to Mineralogy. His primary object was to obtain more space for the exhibition of minerals, and a new laboratory of Mineralogy; but a secondary object was to remove this valuable collection from a building which was not fireproof, and which was subject to the risks of chemical experimentation. His efforts were soon crowned with success; and in 1889–90 a section of the Museum devoted to Mineralogy, with a floor area of 13,200 feet, was finished at a cost of $35,000. This area provided not only an exhibition room, but a lecture room, laboratory, and store-rooms. The Mineral Cabinet having been removed from Boylston Hall, it became possible to provide in that building a large laboratory for Organic Chemistry, and a new lecture room seating five hundred students. These changes were made at the cost of the Corporation in 1891, Professor Cooke actively superintending them in all their details.

When a man has started early in enthusiastic pursuit of a worthy object, and has vigorously pursued it through all his active life, it is a sincere satisfaction to all who have observed him, and particularly to all who have been at any time his comrades or followers in the pursuit, to see him, before death comes, reach his goal. Professor Cooke attained and gave this happiness. He himself saw his beloved science taught in the only way he thought wise and effectual, and raised in academic standing to an equal level with the oldest and most valued subjects used in education. He saw large laboratories and lecture rooms, which he had himself planned and built, filled with eager students. And finally he saw the mineral collection, which had been his care and delight for forty-four years, safely and handsomely established in the principal University Museum. Few men see so many of their objects attained, so many of their hopes fulfilled. He had other sources of profound satisfaction, some of which have been already pointed out to-night; it was my part to describe his remarkable and enduring administrative achievements as Erving Professor of Chemistry and Mineralogy in Harvard College.

A LIST OF THE MORE IMPORTANT PUBLICATIONS OF JOSIAH PARSONS COOKE.

Books.

1857. Chemical Problems and Reactions.
1860. Elements of Chemical Physics. New editions in 1866 and 1877.
1864. Religion and Chemistry or Proofs of God's Plan in the Atmosphere and its Elements. New edition in 1880.
1868. Principles of Chemical Philosophy. New editions in 1870, 1875, and revised edition in 1881.
1874. The New Chemistry. New editions in 1876, 1877, 1884 and 1888. Also translations in many languages.
1881. Scientific Culture and Other Essays.
1888. The Credentials of Science the Warrant of Faith. New edition 1893.
1891. Laboratory Practice. A Series of Experiments on the Fundamental Principles of Chemistry.

Papers on his Original Investigations.[1]

1852. Description of a Crystal of Rhombic Arsenic. These Proceedings, III. 86.
1852. Octahedral Crystals of Arsenic. These Proceedings, III. 204.
1854. The Relation between the Atomic Weights. Mem. Am. Acad., New Series, V. Am. J. Sci., [2.], XVII. 387.
1854. On two new Crystalline Compounds of Zinc and Antimony. Am. J. Sci., [2.], XVIII. 229.
1854. On a new Filtering Apparatus. Am. J. Sci., [2.], XVIII. 127.
1855. On the Law of Definite Proportions in the Compounds of Zinc and Antimony. Am. J. Sci., [2.], XX. 222.
1860. Crystalline Form not necessarily an Indication of Definite Chemical Composition. Am. J. Sci., [2.], XXX. 194. Phil. Mag., XIX. 405.
1861. On the Dimorphism of Arsenic, Antimony, and Zinc. Am. J. Sci., [2.], XXXI. 191.
1862. On the Spectroscope. Am. J. Sci., [2.], XXXIV. 299.
1863. On the Cleavage of Galena. Am. J. Sci., [2.], XXXV. 126.
1863. An Improved Spectroscope. Am. J. Sci., [2.], XXXVI. 266.
1863. Crystallographic Examination of Childrenite. Am. J. Sci., [2.], XXXVI. 257.
1864. Crystallographic Examination of the Acid Tartrates of Caesia and Rubidia. Am. J. Sci., [2.], XXXVII. 70.

---

[1] Prepared by T. W. Richards.

1865. On a Spectroscope with many Prisms. Am. J. Sci., [2.], XL. 305.
1865. On the Projection of the Spectra of the Metals. Am. J. Sci., [2.], XL. 243.
1866. On the Aqueous Lines of the Solar Spectrum. Am. J. Sci., [2.], XLI. 17.
1866. Separation of Iron and Alumina. Am. J. Sci., [2.], XLII. 78.
1866. Analysis of Danalite of Rockport. Am. J. Sci., [2.], XLII. 73.
1867. On Cryophyllite. Am. J. Sci., [2.], XLIII. 217.
1867. On Certain Lecture Experiments. Am. J. Sci., [2.], XLIV. 189.
1867. Crystallographic Examination of some American Chlorites. Am. J. Sci., [2.], XLIV. 201.
1867. A Method of Determining the Protoxyd of Iron in Silicates not Soluble in the Ordinary Mineral Acids. Am. J. Sci., [2.], XLIV., 347.
1869. Atomic Ratio. Am. J. Sci., [2.], XLVII., 386.
1874. The Vermiculites. These Proceedings, IX. 35.
1875. Melanosiderite. These Proceedings, X. 451.
1875. On two new Varieties of Vermiculites. With F. A. Gooch. These Proceedings, X. 453.
1876. On a new Mode of Manipulating Hydric Sulphide. These Proceedings, XII. 113.
1876. On the Process of Reverse Filtering. These Proceedings, XII. 124.
1877. Revision of the Atomic Weights of Antimony. These Proceedings, XIII. 1.
1877. Re-examination of Some of the Haloid Compounds of Antimony. These Proceedings, XIII. 72.
1879. The Atomic Weight of Antimony. These Proceedings, XV. 251.
1880. On Argento-antimonious Tartrate. These Proceedings, XIX. 393.
1880. On the Oxidation of Hydrochloric Acid Solutions of Antimony in the Atmosphere. Am. J. Sci., [3.], XIX. 464.
1881. On the Solubility of Chloride of Silver in Water. Am. J. Sci., [3.], XXI. 220.
1881. Additional Experiments on the Atomic Weight of Antimony. These Proceedings, XVII. 1.
1881. The Boiling Point of Iodide of Antimony and a new Form of Air Thermometer. These Proceedings, XVII. 22.
1883. A Simple Method for Correcting the Weight of a Body for the Buoyancy of the Atmosphere when the Volume is Unknown. Am. J. Sci., [3.], XXVI. 38.
1883. Possible Variability of the Law of Definite Proportions. Am. J. Sci., [3.], XXVI. 310.

1887. The Relative Values of the Atomic Weights of Oxygen and Hydrogen. With T. W. Richards. These Proceedings, XXIII. 149.

1888. Additional Note on the Relative Values of the Atomic Weights of Oxygen and Hydrogen. With T. W. Richards. These Proceedings, XXIII. 182.

1889. On a New Method of Determining Gas-densities. These Proceedings, XXIV. 202.

Papers on Other Subjects.

1862. Review of Trollope's North America. No. Am. Rev., XCV. 416.

1865. On the Heat of Friction. These Proceedings, VI.

1871. Memoir of Thomas Graham. Am. J. Sci.

1871. Absolute System of Electrical Measurements. Collected Papers from Journal of Franklin Institute.

1874. The Nobility of Knowledge. An Address delivered before the Free Institute of Worcester. Pop. Sci. Month., V. 610.

1875. Scientific Culture. Pop. Sci. Month., VII. 511.

1875. "Gas." Johnson's Cyclopædia.

1875. "Molecules." American Cyclopædia.

1877. Chemical and Physical Researches by Thomas Graham. Am. J. Sci., [2.], XIV. 152.

1878. The Radiometer: a Fresh Evidence of a Molecular Universe. Pop. Sci. Month., XIII. 1. Also Am. J. Sci., [3.], XIV. 231.

1878. Chemical Philosophy. Am. J. Sci., [3.], XV. 211.

1880. In Memoriam Josiah Parsons Cooke.

1880. Notice of Berthelot's Thermo-Chemistry. Am. J. Sci., [3.], XIX. 261.

1881. Memoir of William Hallowes Miller. These Proceedings, XVI. 461.

1881. Notice of the Investigation of Dr. J. W. Brühl on the Relations between Molecular Structure of Organic Compounds and their Refractive Power. Am. J. Sci., [3.], XXI. 70.

1881. Notice of Julius Thomsen's Thermo-chemical Investigation of the Molecular Structure of Hydrocarbon Compounds. Am. J. Sci., [3.], XXI. 88.

1883. The Greek Question. Pop. Sci. Month., XXIV. 1.

1883. Memoir of John Bacon. These Proceedings, XVIII. 419.

1883. Memoir of William Barton Rogers. Ibid., 428.

1884. Memoir of J. B. A. Dumas. These Proceedings, XIX. 545.

1884. Memoir of C. A. Wurtz. Ibid., 568.

1884. Further Remarks on the Greek Question. Pop. Sci. Month.

1885. Memoir of Benjamin Silliman. These Proceedings, XX. 523.

1886. Descriptive List of Experiments for Use in Chemistry B.

1886. The New Requisitions for Admission at Harvard College. Pop. Sci. Month., XXX. 195.
1889. The Chemical Elements. History of the Conception which this Term involves. Pop. Sci. Month., XXXIV. 733.
1889. Address at the Commencement Dinner.
1889. Concluding Address to the Freshman Class of Harvard College.
1890. Report of the Director of the Chemical Laboratory of Harvard College. Presented to the Visiting Committee of the Overseers.
1890. A Plea for Liberal Culture.
1892. The Value and Limitations of Laboratory Practice in a Scheme of Liberal Education.
1892. Memoir of Joseph Lovering. These Proceedings, XXVII. 372.

Also many Reviews and Reports, including Annual Reports as Director of the Chemical Laboratory during many years.

Eight hundred and seventy-first Meeting.

January 9, 1895. — STATED MEETING.

The PRESIDENT in the chair.

The election of two Vice-Presidents to fill the vacancies occasioned by the amendment of the Statutes adopted on the 10th of October, 1894, resulted in the choice of

BENJAMIN A. GOULD, Vice-President for Class I.
GEORGE L. GOODALE, Vice-President for Class II.

The following gentlemen were elected members of the Academy: —

Robert Tracy Jackson, of Boston, to be a Resident Fellow in Class II., Section 1 (Geology, Mineralogy, and Physics of the Globe).

John Eliot Wolff, of Cambridge, to be a Resident Fellow in Class II., Section 1.

Samuel Fessenden Clarke, of Williamstown, to be a Resident Fellow in Class II., Section 3 (Zoölogy and Physiology).

William Thomas Councilman, of Boston, to be a Resident Fellow in Class II., Section 3.

Charles Benedict Davenport, of Cambridge, to be a Resident Fellow in Class II., Section 3.

John Sterling Kingsley, of Somerville, to be a Resident Fellow in Class II., Section 3.

George Howard Parker, of Cambridge, to be a Resident Fellow in Class II., Section 3.

William McMichael Woodworth, of Cambridge, to be a Resident Fellow in Class II., Section 3.

Charles L. Jackson proposed certain changes in the Statutes. This subject was referred to a committee, consisting of C. L. Jackson, A. Lowell, and F. H. Storer.

Henry P. Bowditch, Chairman of the Committee on the Library, read a statement in reference to the expenditures on account of the library, during the last five years. After some discussion, the matter was referred to a committee, consisting of the Librarian, the Treasurer, and the Chairman of the Rumford Committee, with instructions to consider the advisability of appropriating a portion of the income of the Rumford Fund toward defraying the expenses of the library.

On the motion of Charles S. Minot, it was

Voted, To refer the matter of expenditures both for Publications and for the Library to a committee, consisting of the Committee of Publication and the Committee on the Library, the chairman of this committee to be the Chairman of the Committee of Publication.

Edward L. Mark alluded to the "List of serial Publications taken in the Principal Libraries of Boston and Cambridge," published in 1878, and spoke of the need of a new and revised edition of this list. After some discussion, it was

Voted, To call the attention of the Trustees of the Boston Public Library to this matter.

Franklin B. Stephenson read a paper entitled, "Congenital Spots on Annamites, a Means of Racial Identification."

The following papers were read by title: —

Studies on Morphogenesis. III. On the Acclimatization of Organisms to High Temperatures. By Charles B. Davenport and W. E. Castle.

On the Occlusion of Baric Chloride by Baric Sulphate. By T. W. Richards and H. G. Parker.

Eight hundred and seventy-second Meeting.

February 13, 1895.

VICE-PRESIDENT B. A. GOULD in the chair.

The chair announced the death of Arthur Cayley and of Sir John R. Seeley, Foreign Honorary Members.

The Corresponding Secretary read the following letters: from S. F. Clarke, of Williamstown, acknowledging his election as Resident Fellow; and from the National Society of Horticulture of Paris, announcing the death of its Secretary, Pierre Etienne Simon Duchartre. He also read an invitation circular from the organizing committee of the Sixth International Geographical Congress.

Edward Atkinson described the application of heat to the process of cooking according to the principle of Count Rumford, illustrated by demonstrations.

He also exhibited a specimen of calcium carbide (CaC_2). This substance, being dropped into water, readily decomposes, liberating pure acetylene with the formation of calcium hydrate, the reaction being $CaC_2 + 2\,H_2O = C_2H_2 + CaO_2H_2$. The acetylene was lighted with a match, and burnt on the water.

Eight hundred and seventy-third Meeting.

March 13, 1895. — STATED MEETING.

VICE-PRESIDENT B. A. GOULD in the chair.

The chair announced the death of Sir Henry C. Rawlinson and of the Marquis de Saporta, Foreign Honorary Members.

The chair appointed a Nominating Committee, consisting of William R. Livermore, Henry P. Walcott, and Thomas W. Higginson.

The report of the Committee on amending the Statutes was read, and the committee discharged.

In accordance with the recommendation of the Committee, it was

Voted, To amend the second section of Chapter IX. of the Statutes by omitting the words, "and any Resident Fellow who shall remove his domicil from the Commonwealth shall be deemed to have abandoned his Fellowship."

A recommendation to rearrange the sections in Class I. was laid on the table until the next meeting.

The Committee on Appropriations for Publications and for the Library made a report, and, in accordance with a recommendation contained therein, it was

Voted, That the committee issue a circular to the Fellows of the Academy, soliciting subscriptions to meet the expenses of publication.

Voted, To discontinue the purchase of books for the library excepting such as shall be approved by a vote of the Committee on the Library.

On the motion of the Corresponding Secretary, it was

Voted, To meet on adjournment on the second Wednesday in April.

Charles L. Jackson tendered his resignation from the Committee on Appropriations for Publications and for the Library, which was accepted, and the chair appointed Henry W. Haynes member and chairman of the committee.

Henry W. Haynes read a report of the committee appointed to consider the advisability of appropriating a portion of the income of the Rumford Fund toward defraying the expenses of the Library.

The following gentlemen were elected members of the Academy: —

Sir Henry Bessemer, of London, to be a Foreign Honorary Member in Class I., Section 4 (Technology and Engineering), in place of the late Ferdinand M. de Lesseps.

Sven Lovén, of Stockholm, to be a Foreign Honorary Member in Class II., Section 3 (Zoölogy and Physiology), in place of the late Pierre J. Van Beneden.

Sir Frederick Pollock, Bart., of Oxford, to be a Foreign Honorary Member in Class III., Section 1 (Philosophy and Jurisprudence), in place of the late Sir James F. Stephen.

W. R. Livermore gave an informal talk on the political

changes of Europe, from 350 to 1100 A. D., illustrated by a series of seventy-five colored maps, showing the boundaries of each tribe and nation for every ten years.

The following announcement by Henry Taber was read by William E. Story: —

In Volume XVI. p. 130, of the *American Journal of Mathematics* I have shown that certain conditions are satisfied by every orthogonal substitution which is given by the positive square of Cayley's symbolic expression for orthogonal substitutions, in other words, by every orthogonal substitution which is the second power of an orthogonal substitution. I have since found that these conditions are sufficient that a given orthogonal substitution shall be the second power of an orthogonal substitution.

The following papers were read by title: —

On the Action of Ammonia upon Cupriammonium Acetobromide. By Theodore W. Richards and Robert J. Forsyth.

Velocity of Electric Waves. A direct Determination of this Value and a Discussion of its Relation to the Velocity of Light. By John Trowbridge.

Eight hundred and seventy-fourth Meeting.

April 10, 1895. — Adjourned Stated Meeting.

The President in the chair.

In the absence of the Recording Secretary, William R. Livermore was appointed Secretary *pro tempore*.

The chair announced the death of James Edward Oliver, of Ithaca, Associate Fellow.

The Corresponding Secretary read a circular from Emil Diebitsch, soliciting on behalf of Mrs. Josephine Diebitsch Peary subscriptions in aid of a proposed expedition for the relief of Mr. Peary and the promotion of Arctic scientific research.

On the motion of B. A. Gould, it was

Voted, That the Corresponding Secretary be directed to express to Mrs. Peary the regrets of the Academy that the

state of its funds do not permit it to contribute toward the expenses of this expedition.

On the motion of the Corresponding Secretary it was

Voted, To take from the table the report of the Committee on rearranging the sections in Class I.

Voted, To amend Chapter I., Section 1, of the Statutes by changing "Section I. Mathematics; — Section 2. Practical Astronomy and Geodesy; — Section 3. Physics and Chemistry," to "Section 1. Mathematics and Astronomy; — Section 2. Physics; — Section 3. Chemistry."

The Corresponding Secretary proposed that Chapter 9, Section 2, line 8, of the Statutes be amended by changing the word "eight" to "seven." This proposition was referred to a committee, consisting of C. S. Minot, S. C. Chandler, and A. M. Davis.

A report on the subject of appropriations for the ensuing year was read by H. W. Haynes, Chairman of the Joint Committee consisting of the Standing Committees of Publication and on the Library. After discussion, it was

Voted, That the Committee of Publication, the Committee on the Library, and the Treasurer be instructed to report to the Committee of Finance estimates of expenses for the coming year.

Voted, That the money recently raised by subscription be appropriated to printing the current volume of *Proceedings*.

Alexander Agassiz and William M. Woodworth read a paper entitled, "Some Variations in the Genus Eucope."

The following papers were presented by title: —

On Bivalent Carbon. Third Paper: The Chemistry of Cyanogen and Isocyanogen. By J. U. Nef.

A Revision of the Atomic Weight of Zinc. By T. W. Richards and E. F. Rogers.

On the Automorphic Linear Transformation of a Bilinear Form. By Henry Taber.

On the Types of Linear Substitution which transform automorphically a Bilinear Form with Cogredient Variables. By Henry Taber.